BIOLOGICAL EVALUATION OF GYPSY MOTH

AT

ALLEGHENY BALLISTICS LABORATORY

2000

Prepared by

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ABSTRACT

On October 18, 2000, USDA Forest Service personnel conducted a gypsy moth egg mass survey at Allegheny Ballistics Laboratory (ABL). The purposes of this survey were to evaluate gypsy moth population densities and to assess the potential for defoliation and the need for treatment in 2001. Current populations are sufficient to cause noticeable defoliation on approximately 962 acres. Treatment is recommended in 2001, if defoliation and possible tree mortality conflict with the management objectives at ABL.

METHODS

The vast majority of the forested areas at ABL are located on Knobly Mountain and contain susceptible host tree species (primarily oaks) and were included in the survey. The forested areas located within the Potomac River floodplain are comprised mostly of non-susceptible host trees and were not surveyed.

On Knobly Mountain, gypsy moth survey plots were randomly selected based upon available host trees (oak species), size of sample area and uniformity between egg mass counts. At each sample point, a 1/40th acre fixed radius plot was established. The plots consisted of a tally of all the new (2000) egg masses observed on overstory trees, understory vegetation, ground litter and duff. The total number of egg masses observed for each plot was multiplied by 40 to determine the number of egg masses per acre.

Egg mass length was measured at most of the plots to determine the overall "health" of the existing population and as a measure of egg mass fecundity. The average egg mass length (measured in millimeters) and egg mass density (egg masses per acre) were used to estimate defoliation potential (Liebhold et al., 1993).

RESULTS

The location of the survey plots are shown in Figure 1 and the survey results are summarized in Table 1. Egg mass densities ranged from 200-4,840 and averaged 2,155 egg masses per acre. Egg mass lengths throughout ABL tended to be large to extra-large in size and ranged from 26-50 mm and averaged 37 mm.

DISCUSSION

The basic guidelines used to evaluate the risk of defoliation include: previous defoliation events; number of egg masses/acre; size and condition of the egg masses; available preferred food; and risk of larval blow-in following egg hatch. Potential defoliation is categorized as; light (1-30 percent); moderate (31-60 percent); and heavy (61-100 percent).

The survey results indicate that heavy defoliation is likely to occur on approximately 962 acres at ABL in 2001.

This conclusion is further supported when egg density is used as a means of predicting defoliation. Moore and Jones (1987) found that estimating the mean fecundity would increase the precision of gypsy moth density estimates and that a linear relationship exists between egg mass length and fecundity. Further work by Liebhold et al., (1993) demonstrates that the product of the mean egg mass length (mm) and egg mass density provides a more precise means of

estimating population densities and predicting defoliation. Using Liebhold's model, Figure 2 shows how this information can be used to correlate the predicted defoliation of an area. Accordingly, the estimated egg mass density of 2,155 egg masses per acre x 37 mm (average egg mass length) translates to a projected defoliation level of about 69 percent (heavy defoliation). Because egg mass densities and host type are not evenly distributed, actual defoliation will likely range from moderate to heavy throughout the Knobly Mountain area at ABL.

Based on existing egg mass densities and the general size of egg masses, gypsy moth populations appear to be building and healthy throughout all areas surveyed at ABL. The average egg mass length is 37. Egg masses larger than 25 mm typically indicate healthy populations with no obvious stress from either the gypsy moth nucleopolyhedrosis virus (NPV) or the *Entomophaga maimaiga* fungus, two of the primary natural control agents that often express themselves in declining or stressed populations. There was no evidence of either one of these entomopathogens at ABL in 2000. Although it is still possible that either the gypsy moth fungus or the NPV could cause the general collapse of the gypsy moth population next year, it is unlikely that populations will collapse prior to a significant defoliation event occurring in 2001.

Predicting the extent of tree mortality that would occur after one year's defoliation is difficult, however, a stand of trees that is not stressed by other agents during or immediately following a single heavy defoliation will likely pull through with only minor branch dieback and minimal mortality. Trees that are defoliated in excess of 60 percent normally refoliate the same growing season. Such events cause the trees to expend valuable energy reserves to refoliate, and consequently cause the trees' health to deteriorate. Depending on the condition of the trees at the time of defoliation, reduced growth, mast abortion, branch dieback or in some cases tree mortality, has occurred following a single year of heavy defoliation. Should subsequent defoliation occur the following year, the impact is compounded. Trees that receive light-moderate defoliation (< 60 percent) are not likely to refoliate and there is probably no significant impact other than a reduction in growth, reduction of mast and possibly some minor branch dieback.

Trees at greater risk are those that are presently stressed from other factors, such as soil compaction from roads, sidewalks, parking lots, machinery and/or heavy foot travel; over maturity; drought; shock due to recent timber cutting activities; previous year(s) defoliation; and other insect and disease related problems. Droughty conditions have been experienced in this portion of West Virginia during the summer months in 1995, 1997, 1998 and 1999. However, adequate rainfall occurred during the growing season in 2000.

The Allegheny National Forest (1988) and the West Virginia Division of Forestry (1997) provide examples of the potential tree mortality that can occur. On the Allegheny National Forest, untreated stands consisting of 40-80 percent oak, the average loss of basal area (mainly oaks) was about 16 percent (range 3-28) percent) following one year of defoliation and 26 percent (range 10-43 percent) after two consecutive years of defoliation. In a 1986 study area in eastern West Virginia where oak species accounted for 63-78 percent of the species composition, a loss of 25 percent of the total oak sawtimber and 14 percent of the total oak poletimber occurred after one year of moderate to heavy defoliation. In these examples, droughty conditions likely contributed to the level of mortality. Based on observations of the existing health of the forested areas at ABL and the factors mentioned above, extensive tree mortality is not expected should the predicted level of defoliation occur in 2001.

Management Options

For 2001, three management options have been evaluated for managing gypsy moth populations at ABL. The intervention options are offered based upon the following two treatment objectives: 1) protect host tree foliage to prevent tree mortality; and 2) reduce gypsy moth population below the treatment threshold. Each is discussed below.

No Action Option

It is possible that gypsy moth populations could collapse on their own due to the presence of nucleopolyhedrosis virus (NPV) or the more recently recognized fungal pathogen, *Entomophaga maimaiga*. In areas with defoliating level 5 of gypsy moth populations (greater than 750 egg masses per acre) viral epizootics generally manifest themselves after significant tree defoliation has already occurred. Gypsy moth populations will usually peak in 2-3 years once they reach defoliating levels and then collapse as a result of NPV or fungal activity. Residual populations following such a collapse will likely remain at low densities for 3-6 years before rebuilding to defoliating levels. Although it is not possible to accurately assess such events with the information at hand, it is unlikely that a collapse will occur in 2001 since these areas are newly infested and there is an abundance of large healthy egg masses.

Large numbers of gypsy moth caterpillars and defoliation has been shown to impact competing native herbivore arthropods. Sample et al. (1996) showed short-term impacts of both species richness and abundance occurred following light to moderate defoliation events in study plots in West Virginia. It is likely that impacts would be greater as the size of the area and intensity of defoliation increases and be more long term, should extensive tree mortality occur.

Should this option be selected, it is likely that widespread moderate to heavy defoliation will occur at ABL in 2001.

Microbial Insecticide Option

***Btk*:** The only biological insecticide currently registered and commercially available for gypsy moth control is the microbial insecticide *Bacillus thuringienis* variety *kurstaki (B.k)*. This insecticide is available through several manufacturers and has been used extensively in suppression projects throughout the U.S. in both forested and residential areas. *Btk* is a bacterium that acts specifically against lepidopterous larvae as a stomach poison and therefore must be ingested. The major mode of action is by mid-gut paralysis which occurs soon after feeding. This results in a cessation of feeding, and death by starvation. *Btk* is persistent on foliage for about 7-10 days.

Btk has been shown to impact other non-target caterpillars that are actively feeding at the time of treatment. An example of the potential impacts is provided by a study conducted by Miller (1990) in Oregon and Samples, et al. (1996) in West Virginia. Miller's study involved a large-scale (5,000 acres) eradication program where three consecutive applications of *Btk* were applied within a single season. On Garry oak, Miller found that species richness was significantly reduced in treated areas during all 3 years of the study while the total number of immature native Lepidoptera rebounded after the second year. In the Sample study, the areas treated with *Btk* were 50 acre plots and only a single treatment applied. Here too, both species richness and the total numbers of native macro-lepidopterous caterpillars and adults were

reduced but only for less than 1-year. The difference in duration of the impacts between these studies is probably the result of the number of treatment applications applied and the size of the treatment area involved.

Btk formulations are available as flowable concentrates, wettable powders, and emulsifiable suspensions. The normal application rates range from 24-36 billion international units (BIUs) per acre in a single or double application. *Btk* can be applied either undiluted or mixed with water for a total volume of ½-1 gallon per acre. With proper application, foliage protection and some degree of population reduction can be expected with one application and with two applications both foliage protection and a greater degree of population reduction are likely. Because *Btk* is a biological insecticide, the degree of population reduction varies and may depend on, at least in part, the selected application rate, relative health of the population (building vs. declining), population densities, weather (rain and temperature), the feeding activity of the larvae following treatment, and the actual potency of the product.

Gypchek: A second microbial insecticide that is registered and available in limited quantities is the formulated nucleopolyhedrosis virus called Gypchek. This product is not available commercially but is produced in limited quantities by a cooperative effort of the USDA Forest Service and the Animal Plant Health Inspection Service (APHIS). The active ingredient in Gypchek formulations has a very narrow host range (lymnatriids) and occurs naturally in gypsy moth populations. Normally the virus reaches epizootic proportions when gypsy moth populations reach high densities as a result of increased transmission within and between gypsy moth generations. The application of Gypchek to gypsy moth populations simply expedites this process by increasing the exposure of the virus at an earlier stage. Healthy, feeding gypsy moth caterpillars become infected by ingesting contaminated foliage and soon stop feeding and die.

The efficacy of Gypchek treatments to reduce gypsy moth populations has been quite variable. Because of the short period of viral activity on foliage (3-5 days) as well as other biological factors such as feeding activity and weather conditions, it has been difficult at best to project treatment efficacy. Most often foliage protection can be achieved but significant reductions in gypsy moth densities do not always occur. Should inadequate population reduction occur, areas would need to be treated again the following year.

The normal application rate of Gypchek is 2×10^{11} occlusion bodies (OB's) per acre applied in two applications, 3-5 days apart. Due to the limited supply, priority is first given to state and federal cooperators that need to deal with federally listed threatened and endangered species associated with gypsy moth treatments.

Chemical Insecticide Option

The third option is to use a chemical insecticide to control gypsy moth populations. There are currently two chemical insecticides registered for control of gypsy moth populations and approved by the USDA Forest Service for use in cooperative gypsy moth control programs.

Dimilin® (diflubenzuron) is the most widely used chemical insecticide in gypsy moth suppression projects in the U.S. Diflubenzuron (DFB) is an insect growth regulator that disrupts

the normal molting processes of the larvae. The mode of action is to inhibit the formation of chitin, a necessary component of the outer cuticle which causes the affected larvae to die during the molt following treatment. The method of uptake is primarily by ingestion, however, some research has indicated the possibility of absorption through the cuticle as well. DFB is relatively persistent on foliage (24 days) which increases the efficacy on gypsy moth populations but also exposes non-target insects, particularly caterpillars, for a greater period of time.

Dimilin® is registered by EPA for use in residential and forested areas. It is, however, extremely toxic to some aquatic invertebrates and the label prohibits the application over open water or wetlands. DFB is available as an oil based liquid formulation (Dimilin® 4L) and is normally applied in a single application at the standard rate of 1-2 ounces of formulated material per acre. With proper application, foliage protection and a significant population reduction can be expected. The need for treatment of residual populations the following year is normally not necessary.

Mimic®2LV: A second insecticide that has recently been registered for gypsy control is *tebufenozide* or Mimic®2LV. Like Dimilin®, Mimic®is an insect growth regulated but its mode of action differs from that of diflubenzuron. Rather than inhibiting the formation of chitin, tebufenozide mimics the action of the insect molting hormone ecdysone. Upon the ingestion of the material, lepidopterous larvae stop feeding and undergo an incomplete and lethal molt.

As with Dimilin®, Mimic® is more persistent in the environment than Btk and will consequently affect feeding non-target lepidopterous larvae for a greater period of time. It is highly selective to Lepidoptera larvae, however.

Mimic®2LV is available as an oil based liquid formulation and is applied in a single application at the rate of 0.06 pounds of active ingredient per acre. With proper application, foliage protection and a significant population reduction can be expected. The need for treatment of residual populations the following year is normally not necessary.

Alternatives

With the previously described options in mind, the following alternatives are offered.

Alternative 1.	-No action
Alternative 2.	-One aerial application of *Btk* at the rate of 36 BIUs in a total mix of ¾ gallon per acre.
Alternative 3	-Two aerial application of *Btk*, as in alternative 2, applied 4-7 days apart.
Alternative 4	-Two aerial applications of Gypchek at the rate of 2×10^{11} OB's in a total mix of 1 gallon per acre, applied 3-5 days apart.
Alternative 5	-One aerial application of DFB at the rate of 0.75 oz formulated material in a total mix of 1 gallon per acre.

Alternative 6 -One aerial application of Mimic® at the rate of 0.06 pounds of active ingredient in a total mix of 1 gallon per acre.

RECOMMENDATIONS

As previously stated, gypsy moth populations at ABL are healthy, building and sufficient to cause widespread moderate to heavy defoliation in 2001. In order to protect tree foliage and prevent subsequent tree mortality, the recommendation is Alternative 6 (a single application of Mimic) on 962 acres.

Alternative 6 is recommend based on the following considerations.

1) Neither a single application of *Btk*, or a double application of Gypchek is likely to provide adequate foliage protection and a population reduction when applied against a large, healthy and building gypsy moth population. Re-treatment the following year is typically needed.

2) A double application of *Btk* would likely provide foliage protection but population reduction is often variable in healthy building gypsy moth populations..

3) Because of the proximity to the Potomac River, the use of Dimilin® at ABL may require additional precautions to reduce the likelihood of spray material drifting into the river (i.e. wind direction becomes a more critical factor).

4) Mimic® will provide foliage protection and sufficient population reduction such that the need for treating residual populations the following year is unlikely.

5) A single application of Mimic® is much more economical than double applications of other insecticides.

Table 1. – Results of the gypsy moth egg mass survey at the Allegheny Ballistics Laboratory, October 18, 2000.

Plot Number	Number EM/Acre
1	1,920
2	3,340
3	1,960
4	2,480
5	3,540
6	1,000
7	3,240
8	720
9	4,480
10	1,080
11	2,760
12	4,840
13	3,120
14	1,920
15	1,840
16	2,760
17	760
18	1,680
19	360
20	200

Egg mass/acre range = 200-4,840
Egg mass/acre average = 2,155

Egg mass size range (mm) = 26-50
Egg mass size average (mm) = 37

REFERENCES

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Figure 1. Results of the gypsy moth egg mass survey at the Allegheny Ballisitics Laboratory, October 18, 2000.

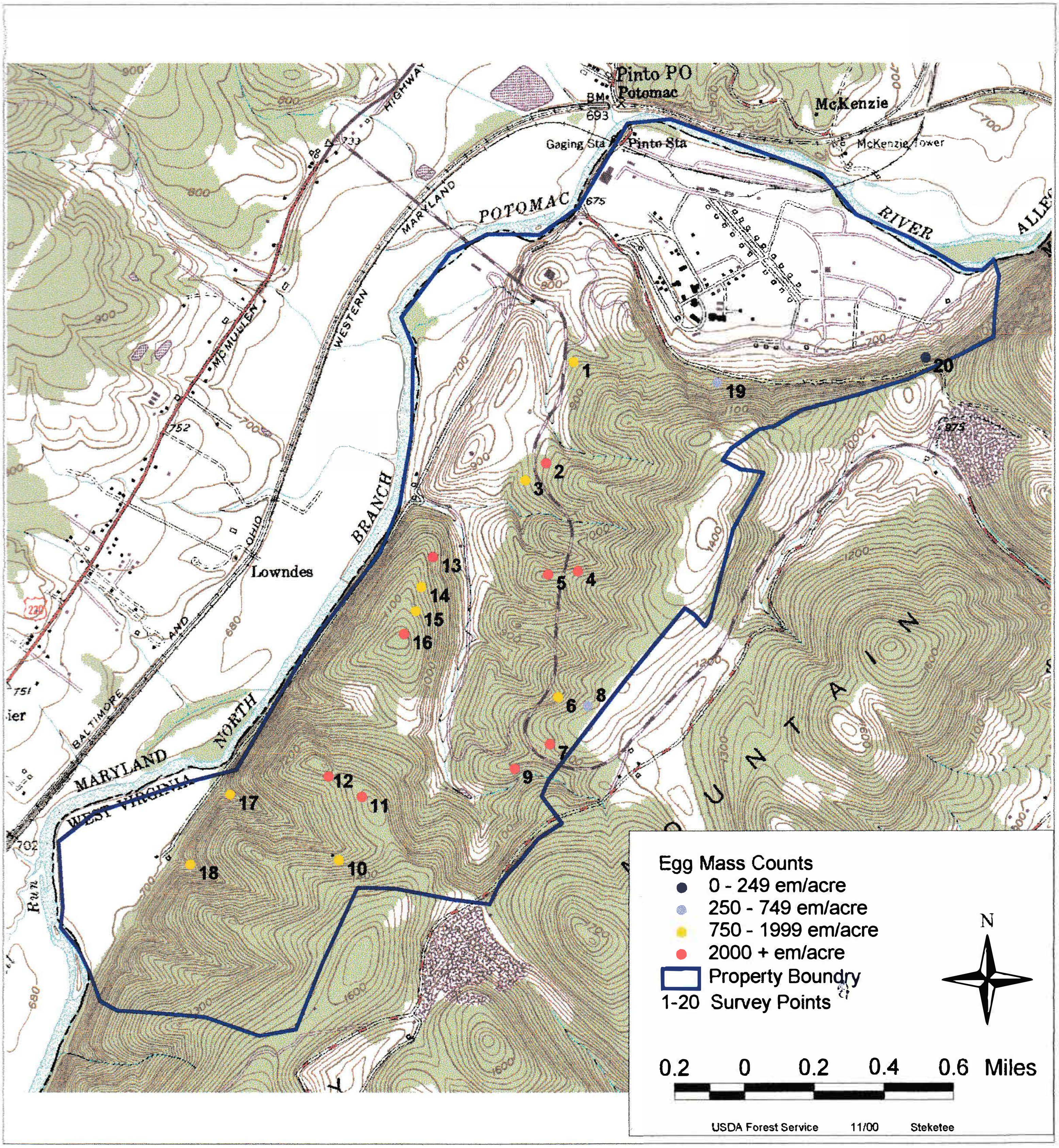
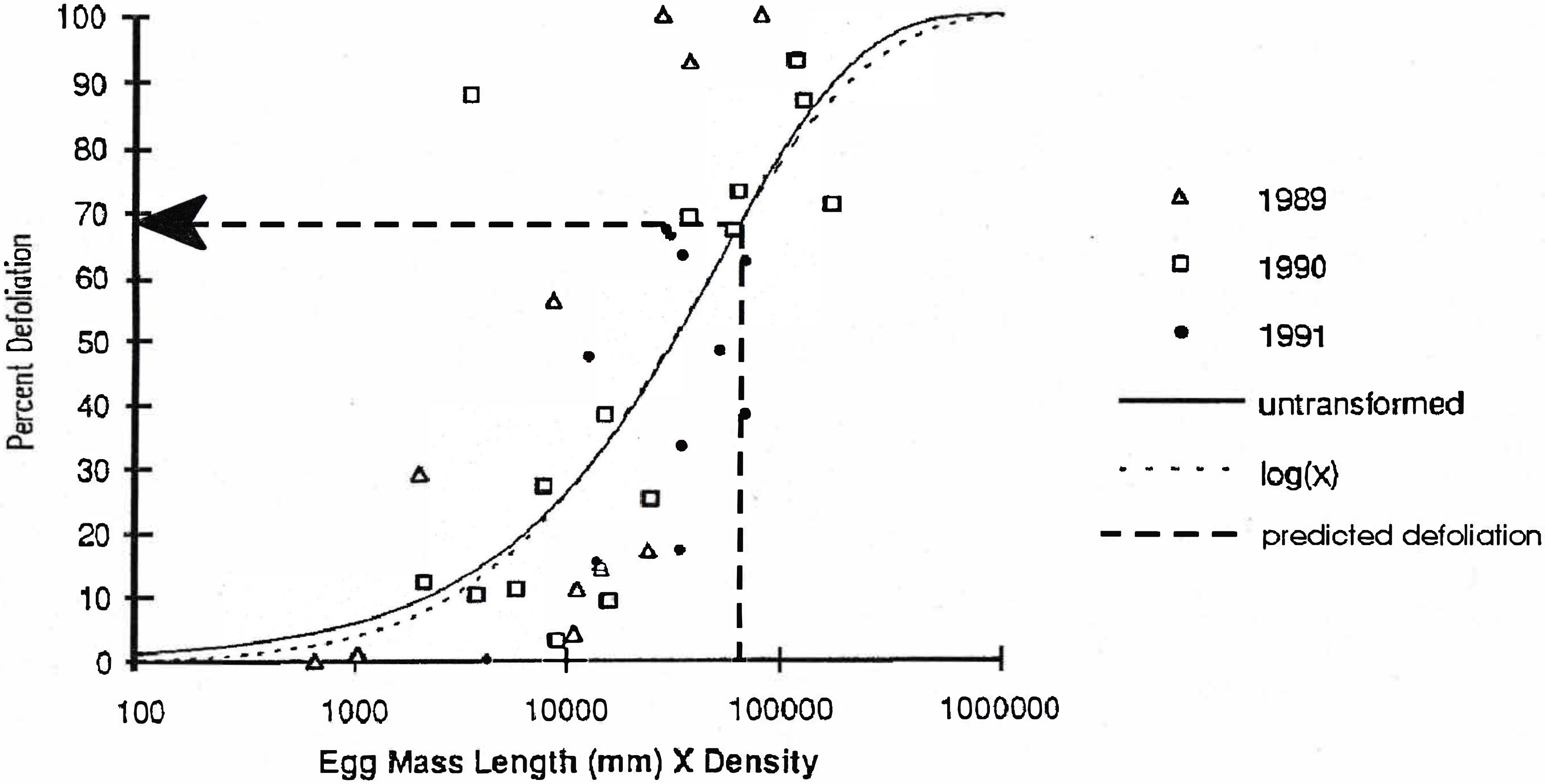


Figure 2.--Predicted defoliation at Allegheny Ballistics Laboratory in 2001 based on egg mass length and density.



Scatter plot of the product of mean egg mass length and egg mass density versus mean defoliation. Extracted from Liebhold et al. (1993).

USDA United States Department of Agriculture | Forest Service | Northeastern Area State and Private Forestry | 180 Canfield Street Morgantown, WV 26505- 3101

2000

File Code: 3400
Date: December 1, 2000

Mr. William Kadow
ABL Navy Program Office
210 State Route 956
Rocket Center, WV 26726-0210

Dear Mr. Kadow:

Enclosed is the gypsy moth biological evaluation at the Allegheny Ballistics Laboratory.

In brief, gypsy moth populations are sufficient to cause widespread defoliation at ABL in 2001. We are recommending a single application of Mimic® on 962 acres. With proper application, gypsy moth defoliation should be minimal.

As it stands currently, the West Virginia Department of Agriculture will be able to include the 962 acres at ABL in their gypsy moth suppression program.

Please contact Rod or Brad at (304) 285-1541 if you have any questions concerning this gypsy moth biological evaluation.

Sincerely,

for
JOHN W. HAZEL
Field Representative
Morgantown Field Office

Enclosure

Cc: Steve Hubner, Navy
Jan Hacker, WVDA
Butch Sayers, WVDA
Noel Schneeberger, AO

JWH/RLW/blm